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Executive Director: EUNICE THOMAS MINER

THE GEOLOGIC HISTORY OF PARÍCUTIN

By FREDERICK H. POUGH*

In spite of the distracting world events which have coincided with its activity, the new Mexican volcano, Parícutin, has been more carefully studied than any other volcano in history. All branches of science have sent their representatives to the site, some 300 miles west of Mexico City in the State of Michoacán, to observe special aspects of the eruption, and to record effects of the vulcanism on the region. The interrelation of the sciences has been well shown by the seemingly unrelated classes of scientists who have found features of their speciality for study. Not the least of their contributions has been the picture record assembled by successive visitors which has preserved transitory aspects of the eruption, and emphasized special features likely to be overlooked by observers specializing in different branches of science.

The film, assembled for geologists, attempts to show many different geological aspects and mechanisms which will be of assistance in teaching students the general features of vulcanism. In showing geologists special details of structures observed in the field it should be an aid in their studies of ancient volcanoes. The pictures were taken almost exclusively *by* geologists. Hence, they are far more valuable *to* geologists than pictures of other volcanoes taken by photographers without geologic training, who merely sought to record spectacular effects without attempting to complete a story. Simple amateur cameras were used, often without the telephoto lenses and other accessories considered essential by the professional photographer. It is a great tribute to the courage of the geologists whose pictures have gone to make up the film, that their pictures surpass anything obtained by the professionals. It should be remembered that they exposed themselves repeatedly to considerable risks to obtain the record.

The record is divided into two parts. It first presents a general view of the geologic setting of Parícutin, placing it in its proper position as a typical cinder cone in a geologic belt punctuated by thousands of such cinder cones, and underscored by the Mexican giants, Popocatépetl, Ixtaccihuatl, Toluca, and Orizaba. No visitor to Mexico can fail to be conscious of the evidences on every hand of recent vulcanism, from the distant snowcapped peaks to the symmetrical cinder cones on the edge of the Federal District. The student of archeology will visit an ancient temple washed by a lake of frozen lava. He will be offered more or less genuine stone implements of volcanic glass by the small boys at almost any archeological site. If he travels east or west from Mexico City, he will ride for miles over volcanic deposits with stratified ash beds pitted by bombs showing in the road cuts, with beautifully formed cones constituting most of the neighboring hills, and with ridges of lava barring his route. From the air, he will see prehistoric lava flows that are still so fresh as to preserve the wave-like rolls on their surface, and the cultivated fields in the leveled craters of the cinder cones. Most of the volcanoes are dead or sleeping, but Popocatépetl still emits faint clouds of gas or steam from time to time to prove

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that Mexico's volcanic belt is still an active geologic zone.

To the geologist then, it is not surprising that the quiet of the afternoon of February 20, 1943, should be interrupted two kilometers from the little village of Parícutin by the explosion of a cloud of gas and incandescent rocks in a depression in a corn field. Within a few days, as the earliest pictures show, the eruption had built a small cone. A column of gas, rock dust, and bombs rose with increasing force from the vent and a new volcano was growing. Lava appeared within a few days, and was recorded in the newsreel pictures of the first week. The early camera-equipped visitors were, unfortunately, simply sightseeing tourists, insufficiently informed on geology to appreciate the value of making a record, hence, most of the early pictures are of limited value. When the geologists first started to document the scene, the volcano was already several hundred feet high, and the thin dust column had changed to a heavy cauliflower type of cloud, rising high in the sky. The lava flows of this period were undoubtedly like the earlier ones, viscous masses advancing slowly by the release of brittle blocks of rock from their cooler margins and then creeping over them as further blocks roll out. Several new lava flows were recorded, as the centers of activity moved from place to place. The partial destruction and reconstruction of the cone have been clearly shown in successive pictures. The behavior of the lava flows changed from time to time as the channel-way up which the lava streamed was warmed to permit the escape of the magma at successively higher temperatures. A new vent, Zapicho, formed, for a few months, an active parasitic cone after which the lava vent migrated to the other side of the cone and centered the pyrotechnics there.

Gradually, the fury of the eruption diminished and the growth of the cone was slowed. Streams of lava spread further and further afield, and in the second year the further town of San Juan met the fate of Parícutin. The residents of both towns were resettled in new town sites, and, with all the possessions which could be transported, set out to build new homes and lives far from *El Monstruo*. A joint American-Mexican scientific committee was formed to ease the way for all sorts of scientific studies. At a time when most of the world was banded together for destructive purposes, it was a welcome sign of a future of international cooperation for joint constructive scientific work. The Mexican government was very generous and exceptionally liberal in welcoming foreign geologists to study their volcano and in affording them every facility to increase the value and the pleasure of their visits. Not one of the scientists who visited Parícutin had any but the pleasantest of feelings for his hosts, and all left with an eagerness to return at the first opportunity; sure proof of the success of the Mexicans' magnanimity.

In 1945, the U. S. Army transported a helicopter to the volcano in order to learn the problems involved in transporting and operating a helicopter some distance from its home base, at a high altitude, and under primitive conditions. Their success in making repeated flights over the cone at a time of year when operation from a more distant airfield would have been impossible, because of the rapid changes in atmospheric conditions, was a favorable augury for the future of helicopters, and their use in geologic reconnaisance if costs permit.

By the end of this year little new took place at Parícutin. Gradually the force and duration of the violent eruptions were wearing down; erosion, slumping, and settling were slowing the growth of the

cone. Floods of lava buried its base, concealing all traces of Zapicho, and effectively reduced the apparent height of the cone some hundred meters. Lava continued to seek a series of changing vents, all more or less related to an inferred zone of faulting and weakness, and then to flow out along the paths of least resistance. By the fifth anniversary, rebirths of violent eruptive activity were shortlived, the cone could be climbed almost at will, while the lava flowed quietly out as a fluid river from a vent near the base of the cone, bursting at irregular and infrequent intervals into a fountaining eruption. After a short, rapid advance, surface movement almost ceased as the deeper lava pooled, flooding flat areas and then breaking out at low spots to pour rapidly down to the next potential lake bed. How long this activity will continue no one can say. While it does, it is the greatest show a geologist, or a tourist, could want.

The Hollywood movie men have neglected the scientific aspects of the volcano, and have made little use of it, except for one short spectacular feature. Scenes from the geologists' pictures were used as background material for an imaginary Mexican legend, since the makers could not at that time get such pictures themselves. The vicinity of the volcano was used for the setting of one important color feature, with the volcano in the background of many scenes, but the makers regrettably failed to call it to the attention of the audience in their acknowledgments and a good opportunity for a little education was neglected.

The second part of the film recapitulates various aspects of the eruption. The day-to-day and year-to-year variations in the dust column are noteworthy. The rapidity with which the column can change from heavy boiling cauliflower-like dust rising 7 kilometers in the air to a faint column of gas and steam marked only by a cloud cap some thousands of meters above the cone is remarkable. Today, the dust column takes the appearance of a light drifting smoke cloud most of the time, and the explosions which force up heavier clouds are infrequent.

The type of explosions, too, was seen to vary from time to time. The earliest were marked by great bursts of incandescent rocks which showered in all directions to limn the cone in fire. At other times, they were more concentrated, with one or two large bombs rising like projectiles, with trails of dust behind, leaping up and outwards as the leading bomb finally bowed to gravity and fell back to earth or landed on the slope of the cone. The more frequent, milder bursts of Zapicho were very different. These threw out shreds of brownish spongy glass that in a few months built up a cone 100 meters high, all composed of small light fragments, with none of the larger, heavier, solid bombs of the main vent. The early bombs were large and fell some distance from the cone in many places. They stripped the branches from the nearby trees which were gradually being buried deeper in the ash deposits. Later showers fell only on the slopes, racing downwards at lightning speed and piling around the base of the cone. Today the bombs are far less abundant, and by far the greater number fall back into the crater itself, probably to be re-ejected time after time until some extra burst or tangential explosion lifts them over the lip so they escape the furnace mouth.

The bombs, themselves, are worthy of note. Few of them appear to have been liquid as they whirled in the air. A few were rounded and bomb-like and rose high enough to come down solid. Some, especially the early ones, were great liquid crusted masses which flattened as they

landed, showing some features of a "breadcrust" but still so liquid within that tiny combs of glass stood up along the cracks as they squashed. Some were fragments of extruded columns, showing grooves and flutings impressed upon them by the die action of crevices through which they were pressed. Rarest were the fragments of the underlying basement rocks through which the lava ate its way as it rose to the surface. By the fifth year these had disappeared entirely, but they were moderately common in the earliest days. Some of this material seemed to show a series of changes with time. That of the first few months contained quartz and feldspar with glassy interstitial matter, but gave the impression of masses of granitic rock. By the next year, the white drops, which appeared not to mix freely with the basalt magma, were more pumiceous in appearance, sometimes forming great white "skulls" coated with black basalt. In the third year, one fragment of a gray and black streaked obsidian was picked up on the slopes of the cone still warm to the touch. This interesting mass of glass was cased with basaltic spongy glass which had peeled back from the obsidian stretching out and cracking apart a clinging shred of brittle glass while the basaltic coating was yet plastic enough to flow.

A series of photographs shows some of the effects of the ash upon the countryside. First killing the nearby trees and filling the gulleys, it smoothed the relief and eased the walking. With advent of a rainy season, however, the gulleys soon were deeper than they had been before. As the plants died and the protection of the vegetation cover lost its effectiveness, erosion was speeded up and flows of mud ferried great boulders out on the flat that could not have been moved by water alone. Floods left a distant power plant meters deep in mud after the waters receded. The destructive effects of the easily transported ash were complicated by the increased rainfall of the immediate vicinity and the gradual decay of the dead plants. Heavy ash deposits on some of the neighboring hills coupled with the rotting of the tree roots that anchored them in the soil created great landslides. The bare trees which once stood stiffly against the skyline now are tumbled masses of sticks pointing in every direction on the steeper slopes where sliding has taken place, lubricated perhaps by the thin humus layer which once marked the forest floor.

The gases, prime mechanism of the eruption, have diminished in quantity with time, as evidenced by the diminution of gas escape from the halted lava flows of more recent date. The early flows were so saturated with gas that fumaroles formed along the front every few meters wherever a crevice permitted their escape. One of the earliest fumaroles has persisted for almost five years and seems still to be giving off gas, even though its vent is now buried under a new flow of lava, a flow that has buried all of the old landmarks near the base. Salts were depositing at the mouths of the vents, largely sal ammoniac in well-formed trapezohedral and dodecahedral crystals up to 5 mm. across. Temperature recordings at the mouths suggested that they were forming at high temperatures, about 300° C, while yellow and orange incrustations formed at greater distances from the vent and at appreciably lower temperatures. Sulphur was conspicuously absent, though SO_2 was noted in the gas of the crater itself. The etched camera lenses reported repeatedly were probably affected by HCl, which was locally abundant. A filter over the lens was a wise precaution at all times.

Higher temperature gases were noted all along the lava flows, whose active

current channel, one might say, could easily be followed by the stream of blue gas vapors (probably also ammonium chloride) rising along its surface. The very liquid flowing lava near the source often rose in great bubbles, some of which occasionally burst, but which more frequently collapsed as the escaping gas leaked from the cracks before the surface broke. Such bubbles could be followed moving along the path of the flow, great drops collecting and rising from the streaming lava as it slowly crept downward. Whirlwinds noted about the flow surfaces were probably unrelated to the escaping gas, but were merely normal atmospheric *remolinos* formed from local heating of the air over the flows.

Great variations were noted in the mechanism of the lava flows. Good fortune gave an opportunity to record the complete history of the birth of a flow. It included the evening's violent activity in the vent to the slump in the cone front, and the appearance some six hours later of the nose of a new lava flow at the foot of the terrace formed as the side of the cone slumped out. The first evidence of the new flow was an increased rate of sliding of the material of the terrace and the appearance of a great rusty boulder of rock which cracked open to reveal a glowing fissure. Soon more and more blocks spalled off and tumbled down into a gulley, and the flow was well started on its way. The rate of advance determined, in a general way, the size of the cascading blocks; the slower the advance, the larger the blocks. Concentration of a plastic flow in a gulley led to a rapid crumbling of the front and the production of small blocks. As the slope flattened out, the rate of progress slowed and the blocks became larger again. Very rapid advances produced liquid yet very viscous lava right at the front, where it rolled forward like a caterpillar tread over a self-formed pavement of small blocks which tumbled off its surface in advance of the tongue. The lava tended to pool, filling up great flat or gently sloping areas, before a current developed. After finding an outlet, the movement became concentrated in a narrow band, often producing an incandescent cascade in a place which had originally been filled by the slow advance of black tumbling blocks. Nearer to the vent, as the pathway of the lava is better defined, the lava becomes increasingly liquid. In the first few months of the eruption almost no liquid lava was seen, though streams of red hot dust which followed down after a block had fallen, created the impression of a liquid. By the second year, the rising lava was warmer. Then, it was very common to see great plastic masses of lava drip off a freshly exposed surface after a block had shattered and a solid crust had tumbled down. Nearer to the vents at this time, it was possible for several weeks to see liquid lava flowing in an open pool. It descended into a lava tunnel through which it advanced for a considerable distance before again coming to the surface where it fed an advancing flow.

By this time, a series of vents was well developed on the west side of the cone and activity ranged from one to the other. The stream escaping from them was liquid for some distance. The surface was so covered with frozen blocks that the incandescence showed only at night, or where a cascade stretched out the flow by increasing its rate of fall. This type of *boca* has continued to function down to the present. The lava, at the last visit, was coming from a similar mouth on the eastern slope. Far away, at the lava front, the flows are of the plastic crumbling block type. The liquid lava is seen only at the mouths.

Often, the interior of a flow may be alive and active, while the surface is so crusted that it can be crossed. Such an opportunity in 1944 gave a chance to see the development of the small gas-formed cones known as *hornitos*. High temperature gas worked its way to the surface as a small crack, ate out the aperture and lined it with ejected fragments of highly reduced metallic looking basaltic glass. The small cones built up solely by the force of the escaping gas. At night these *hornitos* were seen to be topped by blue flickering flames. It was probably burning hydrogen created by the decomposition of water vapor and the abstraction of the oxygen by the lava.

Abundant gas is responsible for the rise of the lava, and its escape to the surface to form Parícutin may be explicable in the same manner as the formation of the *hornitos* on a much smaller scale. A wonderful example of the fluxing, melting effect of the gas was afforded by a nearby view of a lava fountain eruption, during the course of which, within a few minutes, a small unimportant gas vent was eaten out to form a conduit for rising gas and lava. This fountained a hundred meters high and fed a lava stream that flowed rapidly over a small area around the series of western vents in a half hour period. The fountaining can only be explained as a gas lift, for no hydrostatic mechanism seemed to be involved and the activity at neighboring vents was not synchronous. The photographic record of this display, which took place at night, proves the nature of this eruption, and suggests that the abundant gas is probably the principal factor in the birth and the activity of this volcano.*

* The author is very grateful for the many contributions and scientific cooperation which made the assemblage of this film possible. A considerable footage of the film was exposed by Doctor William F. Foshag, of the U. S. National Museum. A short series of important crater shots were made by Carl Fries, of the U. S. Geological Survey. Some magnificent lava flow pictures and of bombs were taken by Tad Nichols. Short sequences which filled gaps in the review of various aspects of the eruption were supplied by many other photographers. The cost of one of the Museum's expeditions and of the duplication of the films were paid by Doctor Otto O. Fisher, a Member of the National Research Council's Committee on Parícutin. Movietone News and Darryl F. Zanuck, of Twentieth-Century Fox Films supplied sequences for the historical review. The Instituto de Geologia of the Universidad de Mexico supplied every facility and transportation for much of the general geological pictures of the setting Parícutin.

SECTION OF BIOLOGY

PROBLEMS IN THE BEHAVIOR AND PHYSIOLOGY OF A SPECIES OF AFRICAN MOUTHBREEDING FISH*

By LESTER R. ARONSON†

Introduction. The purpose of the present discussion is to outline the progress that has been made during the past six years in analyzing the neurological, endocrinological, and psychological mechanisms governing reproductive behavior in teleosts. The Cichlid fish, *Tilapia macrocephala*, was chosen for these studies because of a series of favorable qualities, particularly the fact that it is so well adapted to the rigors of aquarium life. In addition, these fish have an intricate and interesting reproductive pattern which we have studied with the object of finding what biological principles may be involved basically.

Except for a few popular aquarists' reports and taxonomic accounts, there is little in the literature concerning the species studied, or as a matter of fact, concerning the genus *Tilapia* itself. Even concerning the family Cichlidae to which *Tilapia* belongs, biological and psychological studies have been very limited.

* The experiments herein reported were supported by a grant from the Committee for Research in Problems of Sex, National Research Council. The author wishes to acknowledge the assistance of Mrs. Marie Holz-Tucker in the conduct of many of these experiments.

† Department of Animal Behavior, The American Museum of Natural History, New York, N. Y. This paper was presented at the meeting of the Section on November 9, 1948.

Since we were continually handicapped by a lack of basic information, it was not feasible to allow any one phase of our investigation to progress too far ahead of the others.

Description of Mating Activities. Certain of the behavioral patterns which increase in their frequency of occurrence prior to spawning and which lead up to the acts of oviposition and fertilization generally are classified as courtship activity. The condition of such behavior appears to express the level of sexual excitability of the given individual. In accordance with the views of Huxley (1914; 1938), Marshall (1936) and others, it is assumed that courtship tends to hold the pair together and through processes of mutual stimulation may lead to a well synchronized spawning. The courtship patterns which could be distinguished in *Tilapia* have been given descriptive names such as: (1) head-nodding, (2) throat-puffing, (3) tail-slapping, and (4) body-quivering. These patterns have been described in detail elsewhere (Aronson, 1949).

A second group of behavioral activities consists of patterns which are more immediately related to the spawning itself. These include nest-building, passing-nest, spawning-quivers, and the acts of oviposition and fertilization. After a series of egg laying and fertilization cycles, the male swims in the vicinity of the nest for a minute or less, and then rapidly picks up the eggs with his mouth.

The eggs hatch in five days and are carried from seven to twenty days, during which time the embryos continue to develop. The young are released abruptly and most of them are sufficiently developed at this time to suggest that further parental care would not be especially advantageous to them. Parental care ends abruptly with the release of the young. In fact, parents sometimes eat their newly liberated offspring.

One of the most interesting findings relative to these behavior patterns is the lack of any sharp difference between male and female behavior, contrary to the state of affairs in the reproductive behavior of the majority of vertebrates. There is no particular item which can be called strictly the male or female pattern. All of the chief behavioral patterns are exhibited by both sexes. Even the motor acts of oviposition and fertilization are alike and the only way they can be distinguished is by knowing the sex of the individual or by watching the eggs appear from the genital tube of the female while nothing can be seen issuing from the genital tube of the male.

Analysis of the Mating Pattern. To carry this study forward, we took advantage of opportune quantitative techniques (Aronson, 1949). To quantify our data, records were started whenever a spawning seemed likely to occur within three or more hours. Each time one of the previously described behavior patterns appeared, the observer set down the item and time on the data sheet. These records were continued without interruption, in most cases, up to the spawning and for one-half hour thereafter. For the purpose of analyzing the data, the time of appearance of the first batch of eggs was designated as the zero minute. The fifteen minute period just preceding the zero minute was called the first pre-spawning interval. The period fifteen minutes to thirty minutes prior to this zero minute was named the second pre-spawning interval. Twelve pre-spawning intervals were similarly measured and in the same way starting from the zero minute, two post-spawning intervals were measured. The number of times that the various courtship and mating

activities were recorded during each fifteen minute pre- and post-spawning interval was determined for both males and females for all the observed spawnings. Because of the skewed nature of the distributions thus obtained, it was considered appropriate for statistical reasons to employ the transformation $X = \sqrt{x}$. Means of the transformed data were calculated and these were plotted against the time intervals. Typical examples of the graphs so obtained are shown in FIGURES 1, 2, and 3. These graphs and others not shown here indicate the following points:— (1) Male and female reproductive behavior, while qualitatively alike, are exceedingly different quantitatively. (2) In the female, the four courtship patterns, namely, tail-slapping, body-quivering, throat-puffing, and head-nodding all increase in frequency after the spawning, but not so in the male. (3) In the female, nest-building starts decreasing in frequency about an hour before the spawning. (4) Passing-nest increases as the spawning approaches and the quantitative relationships change. Thus, in the earlier pre-spawning periods, the male tends to pass nest, on the average, more than the female, but at fifteen minutes prior to the spawning this relationship changes and the female exhibits more passing-nest than the male. (5) A similar quantitative shift is found in the spawning-quivers. (6) In contrast to the courtship patterns mentioned above, the behavioral activities more intimately related to spawning, namely, nest-building, passing-nest, and spawning-quivers, drop off almost completely immediately after the spawning.

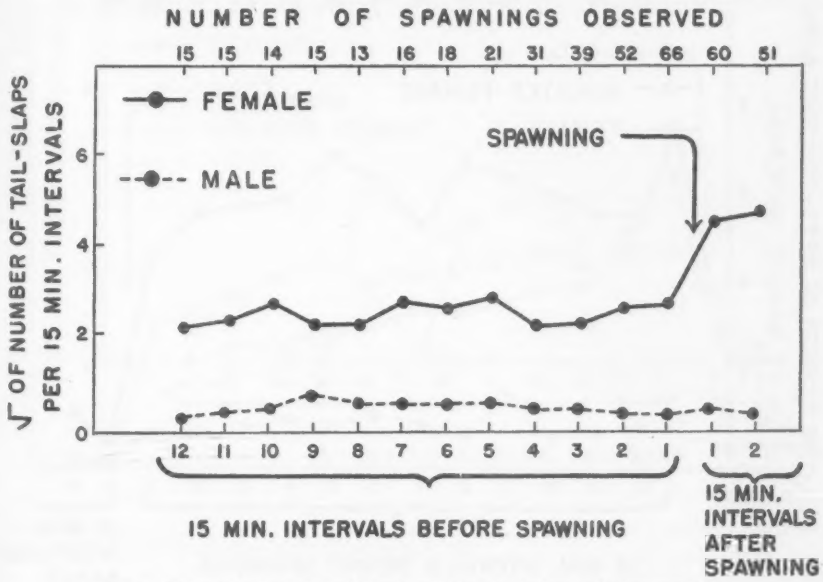
NUMBER OF SPAWNINGS OBSERVED
15 15 14 15 13 16 18 21 31 39 52 66 60 51
FEMALE
MALE
SPAWNING
√ OF NUMBER OF TAIL-SLAPS PER 15 MIN. INTERVALS
0
2
4
6
12 11 10 9 8 7 6 5 4 3 2 1 1 2
15 MIN. INTERVALS BEFORE SPAWNING
15 MIN. INTERVALS AFTER SPAWNING

FIGURE 1. Fluctuation in male and female tail-slapping before and after spawning.

TABLE 1 summarizes some of the data on male and female parental activities. Here, also, a qualitative similarity, but at the same time a pronounced quantitative

difference in the behavior in the two sexes can be seen readily. TABLE 2 shows the variation in length of the incubatory period. We see here that almost 55 per cent of the females swallowed their eggs within eight hours, in contrast to less than five per cent of the males. We also see in TABLE 2 that some females carried food, which evidently accounts for the swallowing of eggs within a few hours after spawning. Second, deterioration of unfertile eggs and dead embryos evidently accounts for the disappearance of spawn between the first and twelfth day. The latter hypothesis is supported by the fact that unfertilized eggs kept in a jar of

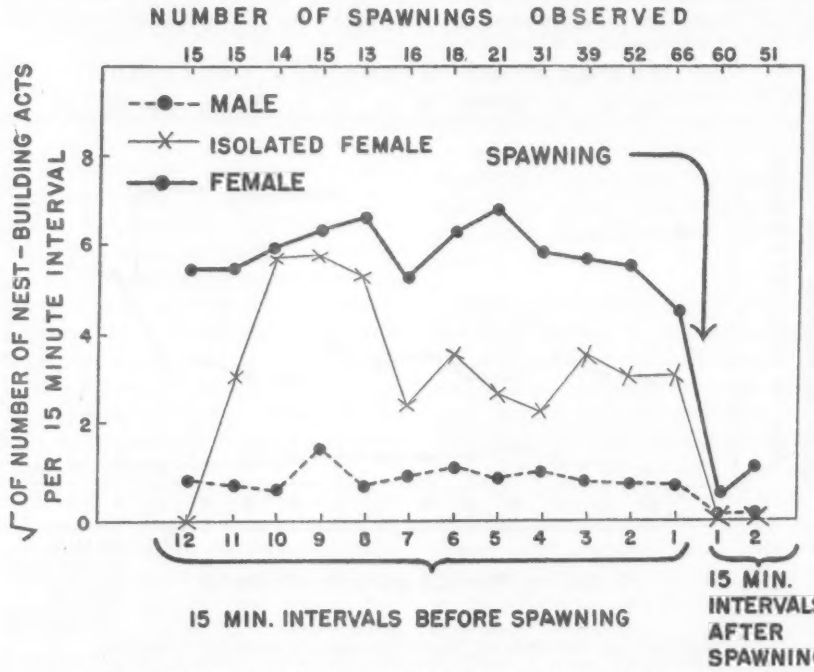

FIGURE 2. Fluctuation in male and female nest-building behavior before and after spawning. The crosses represent the behavior of a single completely isolated female.

eggs successfully, so that viable fry were obtained. Where young were recovered from the male, the mean incubatory time was 13.8 days with a standard deviation of ±2.6 days. This would give us a theoretical incubatory range of 6 to 22 days. Where no young were recovered (columns 2 to 5 of TABLE 2), two factors appear to be involved. First, there was a failure to discriminate between eggs and aquarium water will start deteriorating after one day, although ten or eleven days may elapse before the batch is completely gone. The fish have never been seen to spit out dead eggs or embryos. These data on the incubatory period augment our emphasis upon quantitative differences between male and female behavior.

Each aspect of the pattern was examined in its relation to the whole. For example,

incubating *Tilapia* generally carry some gravel intermingled with the eggs. Of sixty-three fish examined on the day or day after the egg laying, 95 per cent were carrying one or more pieces of gravel. Generally, between 25 and 50 pieces were found, and occasionally the count went much higher. By the use of aquaria lacking gravel, we were able to demonstrate (Aronson and Holz-Tucker, ms. in preparation) that the presence of gravel in the mouth bears no relation to the survival of the embryos. It is probably picked up accidentally with the eggs.

Experiments on Stimulative Relationships. From preliminary observations that isolated females occasionally spawned by themselves, the question arose whether the male may influence the oviposition frequency of the female. To test this matter, situations were arranged as follows (Aronson, 1945): (1) male and female together in a fifteen gallon tank (control); (2) male and female separated by a transparent glass fence so that water circulated freely, but the fish could not touch each other; (3) male and female separated by a transparent glass partition cemented into

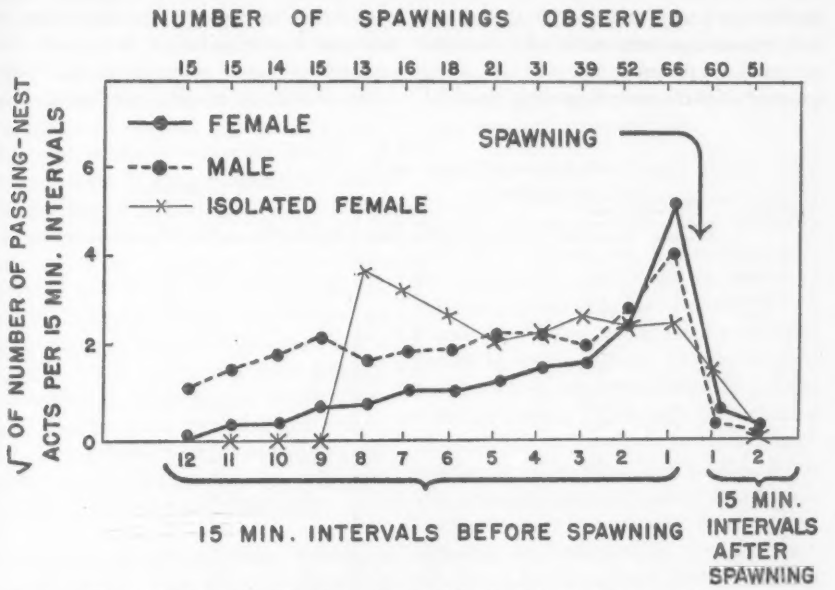
NUMBER OF SPAWNINGS OBSERVED
15 15 14 15 13 16 18 21 31 39 52 66 60 51
√ OF NUMBER OF PASSING-NEST ACTS PER 15 MIN. INTERVALS
FEMALE
MALE
ISOLATED FEMALE
SPAWNING
0
2
4
6
12 11 10 9 8 7 6 5 4 3 2 1
1 2
15 MIN. INTERVALS BEFORE SPAWNING
15 MIN. INTERVALS AFTER SPAWNING

FIGURE 3. Fluctuation in male and female passing-nest behavior before and after spawning. The crosses represent the behavior of a single completely isolated female.

TABLE 1

COMPARISON OF MALE AND FEMALE PARENTAL BEHAVIOR (76 SPAWNINGS)

	Male	*Female*	*Both*
Eggs picked up by	82%	8%	10%
Av. time after oviposition for fish to start picking eggs	1′3″ ± 3″*	7′59″ ± 1′22″	
Time taken to pick up eggs	13″ ± 2″	2′6″	

* Standard error of mean.

the aquarium; (4) male and female separated by an opaque glass partition cemented into the aquarium; (5) male and female in separate aquaria with transparent adjacent walls; (6) male and female in separate adjacent aquaria, all walls opaque. Each of these six conditions was duplicated nine times, and all pairs of fish were run for one year, during which time all of their spawnings were recorded. Females separated from males by a glass fence spawned slightly more frequently than did the controls, but it is questionable whether the difference is significant. The females separated from males by a transparent partition or by transparent walls spawned as frequently as did the controls, but females which were visually isolated from the males spawned considerably less. The results of this experiment indicate that females which are visually isolated from males continue to spawn at a very low frequency, but that stimulation from a visible male will increase spawning frequency considerably. Further analysis of the data suggested an irregular recurrence of events consisting of short cycles interspersed by one or more long cycles. In completely isolated females, the number of short cycles was considerably reduced or was barely in evidence. Hartman (1939) has suggested the probability that all vertebrate classes may be divisible like mammals into two groups, according to whether sex stimulation is required for ovulation. Since oviposition in *Tilapia* is an indication of prior ovulation, this species would appear to represent a third or intermediate category, in which ovulation can occur spontaneously in complete isolation, but where the presence of a male may stimulate the ovary (probably indirectly *via* the optic centers and anterior pituitary) with the result that ovulation and oviposition occur more frequently. Moreover, from the literature on vertebrate reproduction, although it is rather limited on this point, we find that vertebrate species may be arranged in a series, starting with those animals in which the

TABLE 2

VARIATION IN LENGTH OF INCUBATORY PERIOD

Length of incubation	No young recovered				Young recovered			
	Incubated by males		Incubated by females		Incubated by males		Incubated by females	
	No. of males	Per cent of males	No. of females	Per cent of females	No. of males	Per cent of males	No. of females	Per cent of females
0– 1 hr.	1	2.2	5	45.5				
1– 8 hr.	1	2.2	1	9.1				
8–24 hr.	6	13.3	0	0.0				
2 days	7	15.6	1	9.1				
3 "	13	28.9	1	9.1				
4 "	10	22.2	2	18.2				
5 "	1	2.2	0	0.0				
6 "	2	4.4	1	9.1				
7 "	1	2.2			1	1.2		
8 "	0	0.0			1	1.2		
9 "	0	0.0			1	1.2		
10 "	2	4.4			2	2.5		
11 "	1	2.2			12	14.1		
12 "					8	9.4		
13 "					18	21.2		
14 "					12	14.1		
15 "					9	10.6		
16 "					4	4.7	1	33.3
17 "					11	12.9	1	33.3
18 "					2	2.5		
19 "					1	1.2	1	33.3
20 "					3	3.5		

ovarian mechanism is not influenced, or is only slightly influenced by stimulation derived from the members of the same or opposite sex, and ending with species in which ovulation wholly depends upon stimulation from a male or a second female. Between these two extremes we may expect to find many gradations as concerns the role of exteroceptive factors in sexual relationships.

In a second experiment, it was demonstrated that a female is at least as effective a stimulus to a second female as a normal male and possibly somewhat better. A castrate male is equally effective, but a castrate female appears to be somewhat less effective as stimulus, although we cannot rely too much on this point because of the small size of our samples. During this experiment there was no opportunity to watch the behavior of the stimulus fish or the experimental females, but eventual observations along these lines, together with tests of castrate males and castrate females, may shed some light on the question of a possible equivalence of stimuli under these two conditions.

Spawning of an Isolated Female. We have been fortunate thus far in obtaining one good record of the pre-spawning and spawning behavior of an isolated female. None of the early courtship acts was exhibited by this isolated female during a two and one-half hour interval preceding the spawning. On the other hand, nest-building appeared in evidence and was well within the range of variability for females of normal pairs (FIGURE 2).

This female also exhibited passing-nest behavior and this too was within the normal range (FIGURE 3). She performed a normal number of oviposition movements and then picked up the eggs after thirteen minutes and five seconds, a time interval that would be expected for a normal female. Finally, she swallowed the eggs within a very short time, which, as we have pointed out, many of the females do. It is hoped through additional data to ascertain whether the performance of early courtship patterns depends upon a simple visual effect of another fish, or perhaps concerns a higher level of sexual arousal which might ensue when another fish is visible. These observations emphasize once more a distinction between courtship patterns and those acts which are closely related to spawning.

Behavior of Female-female Pairs. Also studied was the behavior of a considerable number of female-female pairs (Aronson and Holz-Tucker, *ms.* in preparation). By observing courtship and nest-building behavior, it was possible to predict which female would lay the eggs and which fish would be the non-layer, for one of them would behave as a typical female and the other as a male. Although the behavior of these paired females was qualitatively similar in all respects, the frequencies of the responses bore the same relation in their case as in normal male-female pairs. This may be illustrated by the occurrence of passing-nest in several pairs, in which for about an hour before spawning the non-layer (*i.e.*, the acting male) carried out more of the passing-nest, while at the fifteen minute interval before spawning, the "layer" generally made the higher passing-nest score. Immediately after oviposition, the non-layer would rub her genital tube over the spawn,—an act reminiscent of a male fertilizing eggs. As concerns picking up the eggs, although the distinction was less clear in such pairs, still the non-layer picked up the eggs in more cases than did the layer, and the latency of this act for non-layers was less than for layers.

Thus, we see that the patterns for male

and female are not altogether rigid, but depend to a considerable extent upon the effective social situation at the moment. In recent years, we have reached an increasing appreciation of the extent to which these reproductive patterns are flexible. The fact is that bi-sexual or homosexual behavior may depend to a considerable extent on social and environmental influences. As concerns the lower vertebrates, the tendency to think in terms of rigidly fixed instinctive patterns still predominates. Our findings suggest that social influences may have a considerable and variable importance even at the teleost level.

the red of the gills may be seen. The opercula of immature individuals contain silvery iridescent guanine crystals. As the females mature, the guanine dissolves or disappears in the center of the operculum leaving a clear area. As the males mature, the silvery guanine crystals assume a yellow iridescence, and concomitantly yellow chromatophores appear in the dermis. Following castration in both male and female, the silvery guanine reappears and the operculum consequently is similar to that of the immatures.

A second structure that interested us is the genital tube, a small flaccid papilla that becomes erect and extended just before oviposition. The oviduct or sperm duct ends in this papilla as does the mesonephric duct.

TABLE 3
PLAN OF ENDOCRINE EXPERIMENT

Groups	*No. of Individuals*	*Weekly Injection*
Intact—Non-injected (Control)	4	—
Intact—Sesame oil	5	.05 cc. oil
Intact—Testosterone Propionate	5	1.0 mg. in .05 cc. oil
Intact—Estradiol Benzoate	4	.2 mg. in .05 cc. oil
Castrate—Non-injected	6	—
Castrate—Sesame oil	7	.05 cc. oil
Castrate—Testosterone Propionate	5	1.0 mg. in .05 cc. oil
Castrate—Estradiol Benzoate	6	.2 mg. in .05 cc. oil

Endocrine Experiments. Plans are being made to study the behavior of castrate males and castrate females paired with normal females, and to follow up the anticipated behavior changes with hormone therapy. However, due to the scattered condition of the endocrine literature on fish and especially because nothing was known at the time about castration and hormone treatment in *Tilapia*, it was necessary to begin by investigating the effects of castration and hormone replacement on the more easily studied morphological characters (Aronson and Holz-Tucker, ms. in preparation).

The operculum of the male is a bright golden yellow color; that of the female has a deep red spot in the center. This spot, we found, actually is a semitransparent window in the operculum through which

Young mature females weighing between three and eight grams were divided into eight groups having almost the same average weight and length (TABLE 3). On alternate weeks, we measured the weight, standard length, genital tube length, and coloration of the central zone of the operculum, using the Munsell color charts. All individuals received their first injection on the day of castration and every two weeks thereafter. The treatments were started on the 88th day and were given weekly thereafter for 22 weeks, the final injection coming on the 239th day. Just two of the measured characteristics will be considered here, namely the genital tube length and the

operculum coloration. Genital tube lengths continued to increase in the controls and in the intact animals treated with sesame oil. In the castrates, the genital tube lengths dropped very rapidly and in some cases the genital tube disappeared almost completely. Following treatment with both testosterone and estradiol, the genital tubes increased rapidly in size and continued to rise parallel to the controls. At the termination of the experiment they were only slightly smaller than the controls and probably not significantly so.

The opercula were unaffected in the controls and in the intact sesame oil treated animals. The castrate non-treated females developed silvery opercula similar to those of immatures. The castrate females receiving testosterone developed yellow opercula like those characteristic of the males. Intact females receiving testosterone also developed yellow opercula. The results up to this point are what would be expected if the gonadal hormones of *Tilapia* were comparable in action to the mammalian hormones used. However, castrate females receiving estrogen did not redevelop the semi-transparent window in the opercula as we anticipated, despite the fact that estrogen increased the size of the castrate genital tube as mentioned above. Also, intact females receiving estrogen lost the semi-transparent window in their opercula, which developed an appearance resembling that of castrates.

Several alternative hypotheses can be offered to explain these seemingly paradoxical results. The most likely hypothesis is that the hormone produced by the *Tilapia* ovary may not be estradiol, but a steroid sufficiently similar so that estradiol does stimulate growth of the genital tube. It is known in the case of the Bitterling (Bretschneider and Duyvené de Wit, 1947) that a variety of steroids will cause lengthening of the ovipositor, and it is likely that the genital tube of *Tilapia* and the ovipositor of the Bitterling are homologous tissues having similar growth characteristics. In the intact estradiol-treated fish, the injected hormone may have maintained the genital tubes but at the same time may have inhibited the ovary from secreting a more specific hormone controlling the coloration of the female operculum. Such an inhibition, of course, might work through the pituitary and indirectly on the ovaries. That an inhibition of this kind actually occurs is verified by the fact that the ovaries of the intact estrogen-treated animals were clearly underdeveloped.

Neurological Experiments. Recent mammalian experiments indicate that the cerebral cortex acts as a facilitator of sexual activities which are integrated in lower centers (Beach, 1940; 1947). On the other hand, as a result of the efforts of the neuroanatomists, there is a widespread belief that the forebrain of fish and amphibia is predominantely an olfactory correlation center. Yet, preliminary experiments by the late Dr. G. K. Noble (1936; 1939) indicated that the forebrain of Cichlid fishes serves as a center for the control and integration of social behavior. Because we now have considerable evidence that the reproductive activities of *Tilapia* are largely dominated by visual cues, it is of interest to investigate the functions of the forebrain in relation to reproductive behavior in the fish.

A variety of forebrain lesions and extirpations have been performed. The experiments discussed here involved primarily hemidecerebration and total forebrain ablation. Although the experimental part of this project has been completed, we are still in the process of

sectioning and studying the lesions. The results show that early courtship patterns, throat-puffing, tail-slapping, body-quivering, and head-nodding, are unaffected by hemidecerebration and total decerebration and that actually in some cases they showed a slight increase in frequency of occurrence. On the other hand, behavioral patterns immediately related to the actual spawning, namely nest-building, passing-nest, spawning-quivers, oviposition, and fertilization movements, were clearly affected by forebrain injury,—another fact demonstrating the significance of these two behavioral groupings.

Nest-building decreased slightly after hemidecerebration and very markedly after total decerebration. However, it is important to note that even when the entire forebrain was removed, a certain amount of nest-building by the male was evidenced in some cases. Passing-nest decreased noticeably after hemidecerebration and very markedly after total decerebration. Here also, it is important to notice that in some of the total decerebrates, passing-nest was not completely eliminated. Whereas one hundred per cent of intact males exhibited fertilization behavior in the presence of newly laid eggs, just 91 per cent of the hemidecerebrates showed this behavior and only eight per cent of the total decerebrates. A considerable percentage of the total decerebrates failed to pick up the eggs, and similarly when the incubatory periods were measured, we found a partial dropping off with hemidecerebrates and a much greater decrease with total decerebrates. A small percentage of the hemidecerebrates incubated the young successfully, but none of the total decerebrates succeeded.

In a series of cerebellar ablations the operated males spawned just as would normal males. This eliminated the possibility that the disturbances might be caused by a general trauma. The results of a series of smaller extirpations in various parts of the brain have not been analyzed in detail, but, in general, they show a slighter degree of disturbance of the reproductive behavior patterns. The tentative conclusion to be drawn from these studies is that the forebrain does not integrate any of the behavioral patterns, but rather facilitates the functioning of other parts of the brain which more precisely control these activities.

Experiments now in the planning stage are designed to determine how the psychological, endocrinological, and neurological factors are interrelated in the control of these reproductive patterns.

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Note. The Division of Mycology held a meeting on November 26, 1948, at which Doctor William J. Robbins, Director, New York Botanical Garden, N. Y., presented a paper entitled "*Some Observations on the Physiology of Trichophyton Mentagrophytes*," illustrated by lantern slides. This will be published in a later number of Transactions.

SECTION OF PSYCHOLOGY

THE PSYCHOLOGICAL PRINCIPLES IN THE DIAGNOSTIC AND THERAPEUTIC APPLICATIONS OF HYPNOSIS

By ROBERT D. WEITZ*

Historical Introduction. As long as man tried to influence his fellowman, hypnotism has existed in one form or another. The medicine men, witch doctors and religious leaders of primitive tribes, the philosophers, physicians and political dictators of more advanced cultures, and the showmen of all epochs have made both constructive and destructive use of this phenomenon. When the fakirs of the East throw a rope into the air and it becomes a snake, a form of mass hypnosis is no doubt present, and when they induce states of rigidity and insensitivity to pain, this, again, is hypnosis. When the primitive medicine man stretches a tribesman who is in pain out upon the ground, and murmurs solemn, monotonous, devil-dispelling incantations over him while he gently massages the afflicted part and touches it with his lips, and finally dramatically expels a stone from his mouth as he tells the patient that he has driven out the pain-devil, this, too, is hypnosis.

Currently, we are all familiar with the showman who calls up someone from the theatre audience, hypnotizes him and forces him to perform all sorts of antics which make him appear ridiculous in the eyes of his fellowmen. The stage use and the general charlatanism so frequently connected with this time-honored phenomenon, have resulted in its being viewed with suspicion by the public and discredited by many reputable therapists.

Hypnotism, nevertheless, can help materially in the study and treatment of many types of maladjusted personalities and nervous disorders. I propose to show it in its true light, stripped of its glamour and mysticism, as a valuable psychotherapeutic tool which should be taught to responsible, practicing clinical psychotherapists.

Scientific interest in hypnotism dates back to the work of Mesmer, a Viennese physician who produced astounding curative feats during the latter part of the eighteenth century. He became interested in the field after observing the cures of Gassner, a Catholic priest who used this method for getting rid of demons. Mesmer evolved the theory that the body has two poles, like a magnet, which throw off an invisible magnetic fluid, and that illness results from an improper flow of this fluid. He maintained that some people had the power to control this fluid and could cause it to flow from them into a patient and that they could even magnetize objects which would then impart the fluid to anyone touching it. Mesmer drew large crowds for treatment. In his chamber, the patients would be seated around a big tub filled with "magnetized" water. Long iron rods which the patients could touch projected from the water. Mesmer, himself, entered the chamber periodically dressed in a flowing robe. In his hand, he carried a long iron rod with which he tapped the afflicted ones. The patient, when properly "magnetized," had a "crisis," or kind of convulsive seizure, and was then cured. Although by nature a showman, Mesmer was undoubtedly sincere and did effect many spectacular cures. Unfortunately, however, his methods aroused much controversy so that finally the French Academy of Sciences, with only one dissenting minority,

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branded him a fraud. "Mesmerism" and "animal magnetism" thereupon rapidly fell into disrepute.

Despite this set-back, other physicians became interested in Mesmer's work. For example, Braid, a Manchester physician, devoted much time to the study of the phenomenon and was responsible for the term "hypnosis" which is in use today. He discounted the magnetism theory and found that a bright object held near the eyes, and suggestion, would produce the trance. Today we know that it is really the suggestion which induces the trance and that the sole purpose of the bright object is to focus the attention of the subject. Braid is said to have used hypnosis in both psychotherapy and in surgery, although the first reported use of hypnosis for a surgical operation was in 1821, when Récamier used it for this purpose. In the United States, Albert Wheeler, a reputable physician, used hypnosis as an anesthetic to remove a polyp from the nose of a patient with a hypnotist acting as anesthetist for him. James Esdaile, a physician employed by the East India Company, also used mentally induced anesthesia in operations and in 1843 induced the British government to build a hospital in Calcutta devoted to hypnotic healing. Although he had tremendous success with his patients, Esdaile eventually shared the fate of Mesmer when a malicious disbeliever paid one of Esdaile's former patients a fat fee to discredit him. The introduction of ether and other physiologically induced anesthesias contributed further to the discard of mentally induced anesthesia.

Shortly after the middle of the nineteenth century, Liebeault and Bernheim in France founded the Nancy school. There they put hypnotism on a scientific foundation, substantiated suggestion as its basis, perfected techniques which are still used in the induction of hypnosis, and used the phenomenon widely in their medical practice. Simultaneously the great French physician, Charcot, worked with hypnosis in his Paris clinic. Unfortunately, however, his work was confined to hystero-epileptics and experimentation with a few women patients, with the result that he rejected the concept of suggestion and concluded that hypnosis was merely an attribute of hysteria and that only such patients could be hypnotized. Alfred Binet, of intelligence test fame, fell in line with this theory and undertook a series of experiments to prove its validity. Now, of course, we no longer find Charcot's theory tenable.

In the early years of the twentieth century, Pierre Janet approached the problem with an experimental study of the trance phenomenon and concluded that the basis of hypnosis was to be found in the weakening of the subject's "mental synthesis." Fitting hypnosis into his theory of dissociation, he explained hypnotic behavior as that which could be split off from the subject's state of consciousness. Janet believed that an individual in the state of hypnosis was especially receptive to direct suggestion aimed at building up the strength of the patient's psyche. He thought that the weakened psyche could be strengthened by the subject's recall of a previously dissociated traumatic experience, thereby saving energy expended by the individual in his repeated attempts at recall of the traumatic experience.

Joseph Breuer, prior to his association with Freud, discovered that hypnosis had therapeutic value insofar as it aided the patient in discharging pent-up energy by reliving disturbing experiences of the past. At first, Freud adopted Breuer's concepts, but later discarded hypnosis in favor of psychoanalysis. Freud's rejection of hypnosis and the growth in popularity of

psychoanalysis were further responsible for the eclipse of hypnotism as a psychotherapeutic method. Recently, though, there has been an up-swing of interest in the phenomenon of the trance state and every effort is now being made to establish the scientific basis of hypnotism and its true usefulness as a psychotherapeutic tool.

All psychological tools which lay claim to scientific value must be based on careful research and experimentation. Many psychological laboratories are currently undertaking this research, so that we can hope soon for a body of knowledge which will give us better insight into the real nature of hypnosis and allied phenomena. The attitude of some academicians makes it a hard fight, but still we can see progress. As Hull writes: ". . . to enter seriously on a program of investigation in this field is a little like tempting fate; it is almost to court scientific disaster. Small wonder that orthodox scientists have usually avoided the subject! Yet each generation may be expected in the future, as in the past, to produce a very few rash souls who will not only risk the dangers of making scientific errors but will also have the courage to brave the semisuperstitious fears of the general public and the uneasy suspicions of their orthodox scientific brethren."[1]

Progress, also, in the practical applications of hypnosis is presently on the move. A greater and greater number of scientifically minded practitioners each day are learning of the many uses to which the phenomena of suggestion and trance may be applied.

Hypnosis as a Psychotherapeutic Tool. In its practical applications, we find hypnosis being used to relieve pain in childbirth and dentistry and in the amelioration of nervous and mental disorders. Unfortunately, however, it is also used freely on public stages as a form of amusement which can hardly be recommended as scientifically therapeutic. We read advertisements in the daily press recommending that you become the "life of the party" by entertaining your friends with hypnosis. Needless to say, all one must have to achieve this "power" is a short course at some disreputable institute. Or worse still, the physically and mentally ill are led to the dimmed chambers of some "witch-doctor" where superficial symptoms are removed by a technique of "out, damned spot." But at what price to the maladjusted!

To understand hypnosis is to recognize that it is not the *sine qua non* of psychological diagnosis and therapy. Hypnosis, at best, is simply one tool, but a valuable tool, available to the competent clinician. To be sure, clinical practice can go on successfully without this technique, but its presence in the armamentarium of those who treat problems of nervous and mental disorders is an important asset.

Unfortunately for all concerned, it is a relatively simple matter to learn any one of a number of methods used to induce hypnosis. Because of this, unqualified persons from all walks of life add hypnosis to their bag of tricks. Far more important than information of how to induce the trance, is the vast amount of knowledge which the clinical hypnotist should possess relative to the psychology of the normal and the abnormal. While the dangers of hypnosis have frequently been overstressed, in my opinion, the fact remains nonetheless that there are situations where hypnosis might definitely be contra-indicated if not dangerous. We shall examine some of these contra-indications later on. Before doing so, it might be well to seek an answer to the question of what hypnosis really is.

What is Hypnosis? Hypnosis has been variously described in terms of mystical, pathological, psychological, and physiological states. Is it a mystical kind of animal magnetism, a form of hysteria or dissociation, heightened suggestibility, a regression to the Oedipus level, a libidinal relationship between subject and hypnotist, a conditioned reflex, a form of brain anemia, or an inhibition of the ganglion cells of the cortex? Or is it, as Warren states in his Dictionary of Psychology, "an artificially induced state, usually (though not always) resembling sleep, but physiologically distinct from it, which is characterized by heightened suggestibility, as a result of which certain sensory, motor and memory abnormalities may be induced more readily than in the normal state.?"[2] A beautiful bouquet of semantics, but what does it all mean? Frankly, I don't know. I don't know what hypnotism is, but I am content for the present to leave it to my experimentally minded colleagues to find out. I am more concerned with the diagnostic and therapeutic implications of hypnosis as a workable tool in clinical practice.

Clinical Aspects and Functions. I have observed many interesting and practical clinical applications of hypnosis but the most important aspect, by far, appears to be its function in aiding the patient to recall or relive repressed experiences of the past. Persons, places, and events are brought back from the subject's unconscious with almost unbelievable clarity and speed *via* the trance. Time and space are traversed rapidly through alteration of the subject's perception. At the therapist's suggestion, during the course of the moment, the calendar is set back years. Space is reduced to nothingness. With this technique, the clinician is able to probe deeply into the past and thereby bring into focus long standing difficulties which, by other methods, often take months or years, if ever, to reach.

Another highly significant value of the trance is seen in the strength of rapport which is established between therapist and patient. By suggestion alone, a temporary strengthening of the patient's ego is effected, thereby enabling him to abreact traumatic experiences of the past or "bridge the gaps" responsible for tension. The strengthened ego surmounts fear and conquers associated inhibitions. Often suggestion serves to stimulate a mental practice effect for the patient which, in turn, encourages him toward further activity in this vein. It is no doubt true that the hypnotist serves as a crutch during this experience, but generally speaking, the patient is able to discard the crutch and stand more firmly on his own feet after having experienced some success in dealing with mental conflict.

A further significant function of hypnosis concerns the induction of relaxation in the patient. Ordinarily the tense individual is preoccupied and ineffectual in dealing with the problems of life. When physically relaxed, the patient's thought processes become less egocentric and increasingly objective, thereby enhancing the progress of readjustment. In the same vein, it has been observed that relaxation is subject to post-hypnotic influence. Frequently, this factor is important in helping the patient overcome hurdles when progress is blocked by his own tensions and inhibitions. You will recall that the importance of physiological relaxation in general adjustment has been experimentally proved by the work of Jacobson[3] and other students of this field. This role of hypnotism has proven especially valuable, for example, in removing the physical barriers of psychosexual frigidity, and in reducing or controlling psychosomatic symp-

toms such as vertigo, headache, choking sensation and shortness of breath, nausea, and fatigue.

Another role of hypnosis is seen in its relation to the problem of conditioning. In this direction, the technique has been used in temporarily curbing undesirable habits such as chain-smoking and alcoholism. In another example of conditioning, I once helped a patient overcome a fear of restaurants by substituting a pleasant olfactory hallucination (cedar wood) for an unpleasant one (vomitus) which the patient had earlier associated with restaurants as a result of a traumatic situation. To be sure, other more basic aspects of the problems involved were necessarily dealt with prior to the examples mentioned above.

Other roles of hypnosis, related, for the most part, to the functions already described above, have been observed. During the trance, the subject shows a markedly improved span of attention which he maintains despite seemingly distracting influences. Verbalization, too, frequently improves under hypnosis. Quiet and reserved subjects, who might ordinarily say very little, open up and speak with ease.

Perhaps one of the most interesting aspects of hypnosis is that which concerns the individual differences that are to be found among subjects. It is generally agreed upon by most students of this field that not all individuals respond equally to hypnosis. It is generally recognized, also, that those who are subject to the trance phenomenon react to suggestion in markedly different patterns. Some writers, notably Wolberg,[4] believe that if attempts at induction of the trance are continued for a long period of time, all persons will ultimately respond favorably to hypnotic suggestion.

On numerous occasions, after having given the patient suggestion to the effect that now he will be unable to open his eyes, and challenge him to perform this task, the patient simply opens his eyes. The look upon his face at that time is usually one which seems to say "Well, what comes next?" Again, on many occasions, I have given post-hypnotic suggestion to the patient, saying that upon coming awake he will remember nothing of what has transpired during the trance. Upon returning to his normal waking state, subtle attempts at questioning will reveal that he is fully aware of all the experiences which took place while he was entranced. Furthermore, several patients have openly stated that they knew they were supposed to forget, yet they recalled everything that took place during the trance.

There is no question, either, in my mind, that subjects respond singularly with respect to the hypnotist who is attempting to induce the trance state. Not long ago, a young lady was referred to me for hypnotherapy after having what she considered to be an unpleasant experience in a psychotherapist's office elsewhere. This young lady, a student of dramatics and voice, was upset greatly when the hypnotist, who was employed for this purpose by the practitioner in question, started his induction of the trance with "*Yu're not afraid of nuttin'*." So shocked was this student of language, that she found herself unable to remain further under the care of this hypnotherapeutic team. She remarked to me during her first interview when questioned as to the reason for giving up her earlier therapist, "I certainly didn't feel that I could trust my mental health to someone who speaks English so badly." While this young lady reacted unfavorably to a matter of diction, certainly there are many, many others who react equally unfavorably to numerous other aspects of the hypnotic relationship.

On the other hand, I have come across individuals who respond completely and deeply at the slightest suggestion. Without prolonged attempts at inducing the trance, these individuals react with cataleptic behavior upon the slightest verbal suggestion to that effect. Why all these differences take place, certainly I do not profess to know, but I might conjecture that these differences are subject to the same forces which make for individual differences among human beings in everyday life.

Indications and Contra-Indications of Hypnosis. Of major importance to the hypnotherapist is the knowledge of when to use and when not to use hypnosis. Disregard of the limiting factors involved may readily lead to serious consequences for all concerned, and increase the already existing distrust of this technique.

First and foremost, hypnosis should be avoided until the possibility of organic etiology of disorder has been ruled out of the picture. This implies, of course, the need of thorough medical examination by a competent physician prior to the use of trance. By exercising this simple precaution, the hypnotherapist protects himself and his patient from treatment failures which are almost certain to result when physical disorder is overlooked or ignored. This does not necessarily imply, however, that hypnosis is without value in regard to problems of a physical nature, for such is not the case. Hypnosis has proved effective for example, in reducing the pain of organic disorder when the use of drugs is contraindicated because of the patient's physical limitations. Hypnosis, furthermore, has been and is presently being used successfully to induce anesthesia for surgical purposes in selected types of cases.

Hypnosis, it would appear, plays its major role as a clinical technique in the study and treatment of the psychoneuroses. Problems of hysteria, phobia, anxiety, etc. are readily handled by this technique. Functional disorders of speech are treated successfully with this method by assisting the patient to talk freely while relaxed. Only recently I heard of a speech case where the patient under hypnosis asked the therapist to permit him to remain in the trance for a little while longer as he enjoyed hearing himself speak smoothly and evenly during his relaxed state.

In short, it would appear that hypnosis is of great value clinically, when applied to those cases where functional disorder is evidenced.

Most writers in the field tend to negate the value of hypnosis in the study and treatment of psychosis. They state that psychotics cannot be hypnotized. On the other hand, these writers warn the therapist against using the trance technique with a potential psychotic, as hypnosis supposedly pushes the borderline case into an active psychotic affair. These writers offer no proof for their claims. This point of view has been disputed recently by therapists who have successfully used hypnosis in the treatment of psychotics.

Not long ago, I assisted a psychiatrist in breaking through to the unconscious of a catatonic schizophrenic who manifested muteness. In this case, the basic conflicts related to the mutism were revealed by automatic writing. Hours after revealing the nature of his conflicts, this catatonic responded favorably under post-hypnotic suggestion and initiated conversation with his father—his first conversation with anyone in several weeks.

Finally, referring once again to the contraindications regarding the use of hypnosis, it is my opinion that the most flagrant violation of its use is evidenced wherever

people gather to be amused by this mystifying but entertaining phenomenon. While it is true that little or no harm may result directly to those who participate in such demonstrations, the fact remains, nevertheless, that great damage is done indirectly to those persons who might require hypnotherapy in the future and directly to the tool itself.

Hypnosis is a scientific method in the hands of competent therapists, but it will never be afforded true scientific status until it is reserved for the exclusive use of those who understand and treat with the psychology of human behavior.

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THEORY OF ESSENTIAL HYPERTENSION IN MAN

By EDMUND JACOBSON*

As previously reported (A.A.A.S.), essential hypertensive disease apparently can be arrested in many cases, at least if methods of progressive relaxation alone are applied persistently. Advanced cases often show marked lowering of pressure which seems to be more than temporary. Occasionally the effects are dramatic. These results—secured without selection of cases—suggest the following theory, wherein we must take into account, reconcile, and harmonize recent advances in the physiology of hypertension by many different investigators.

First, I assume that man differs from the experimental animal in so far as in him hypertensive disease arises as part and parcel of the struggle for existence, which is in more nearly physiological terms the effort to get ahead. This effort differs in various cultures with the general pace of life. On this view, essential hypertension is in part a cultural disorder. If so, it becomes evident why medications, hormones, antirennin, and other procedures which treat man as merely a guinea pig may abate yet fail to solve the basic problem.

We must not overlook the forest, seeing only the trees. Man is self-directing, through skeletal muscle action. Skeletal muscle is approximately the only tissue whereby he can move in whole or in parts and can exert force on external objects.

All effort in man proceeds by shortening of muscle fibers. Evidence has been reported from this Laboratory that this includes not only physical effort but also what is commonly called (or miscalled) mental effort. Muscular relaxation (con-

* Laboratory for Clinical Physiology, Chicago Illinois. This paper, illustrated by lantern slides, was presented at the meeting of the Section on October 18, 1948.

ceived as a limit) can be regarded as freedom from effort, physical and mental.

Twenty years of action-potential measurements of skeletal neuromuscular states during emotional conditions in healthy and in disordered persons have furnished convincing evidence of increased action-potentials. If there is upset or panic, the values recorded can become extremely high. Whether the increased blood pressure which is often observed during emotion derives from the increased neuromuscular tension or directly from central stimulation of blood pressure centers has not been determined. It is also not at all clear to what extent, if any, there is glandular participation in these pressor effects. What is noteworthy, in any event, is that skeletal muscular contractions would appear to be an invariable accompaniment of emotional states and it seems reasonable to assume that to some extent at least the increased pressure results from this factor.

It is generally agreed that hypertonia of the musculature of the arterioles is chiefly responsible in essential hypertension. In early stages this smooth muscle over-exertion is intermittent. As the disease progresses it becomes chronic. However, in this disease hypertonia of smooth muscle is not limited to the arterioles, but at least to some extent, and at some times is more or less generalized.

In relaxed muscle, most capillaries are closed. Upon contraction, they open in increasing numbers, due to the action of metabolites, probably including H. substance. The increased blood pressure is functionally necessary if only to increase the needed supply of sugar and of oxygen and to remove the products of contraction such as carbon dioxide, lactic and pyruvic acid, and other substances of the body. Unless a particular state of effort involves much marked contraction, the rise of blood pressure which attends effort is commonly masked by many complex variables. Upon muscular contraction, the rise probably can be brought about by a variety of routes (rather than one mechanism alone), including complex nervous reflexes, aroused through the stimulation of the muscle spindles during contraction and the action of hormones. Many problems remain to be unravelled concerning the stimulation of the glandular system involved in this complex process. Presumably the glandular system is stimulated directly in these reflexes or else responds chiefly because of hormone action.

The role of the kidney, while still undetermined, may be as follows. Upon skeletal muscular contraction, in sufficient extent and degree, renal arteriolar contraction increases (just like retinal arteriolar contraction), commonly to the point of spasm. Renal anemia, through mechanisms studied by many investigators since Goldblatt's discovery, may result in the production of angiotonin. Perhaps blood is shunted from the renal cortex (Truetta).

We can, thus, understand why in early essential hypertension, renal arteriolar sclerosis is often absent (Smithwick). Admittedly, there are gaps in this mere outline of theory. It is well to lay stress on the overwhelming complexity of the physiology involved. In emphasizing the important role which mental activity plays in the genesis of blood pressure, I note that it is admitted by psychiatrists, including analysts, that psychiatric methods fail to produce lasting lowering of pressure in essential hypertension.

Arteriosclerosis, perhaps, results from wear and tear, especially from excessive effort. Individuals differ in hereditary susceptibility (Ayman).

On this theory, the failure to reduce the death rate from hypertensive disease results from the failure to treat man as a self-directing individual.

SECTION OF PHYSICS AND CHEMISTRY

ISOMERISM OF MACROMOLECULES

By HERMAN MARK

Arrangement of the monomer units in the chain. The first type of isomerism concerns essentially polyvinyl derivatives and has to do with the way in which the monomeric units are arranged in the chain with regard to the sequence of their substituents. It has long been recognized that polyvinyl compounds can occur in two essentially different types, which Marvel has termed the head-to-tail and the head-to-head forms. In the case of polyvinyl chloride, for instance, these two extreme "isomers" would correspond to the following structures:

head-to-tail

$$X\text{—}CH_2\text{—}CHCl\text{—}(CH_2\text{—}CHCl)_x\text{—}CH_2\text{—}CH_2Cl$$

and head-to-head

$$X\text{—}(CH_2\text{—}CHCl\text{—}CHCl\text{—}CH_2)_x\text{—}CH_2\text{—}CH_2Cl$$

In both formulas, X represents some fragment of the initiating catalyst which appears on one end of the macromolecule. It is conceivable that any mixture of head-to-head and head-to-tail arrangement can occur in a given chain and it is, in particular, possible that the two forms may be randomly distributed in the polymer molecule. There exist several experimental methods to decide whether a given material exists in the pure "head-to-tail" or in the "head-to-head" arrangement.

(1) If the polymer under consideration has the capacity to crystallize and gives a well oriented fiber diagram in the stretched state, one has usually the possibility to determine the identity period along the fiber axis. This periodicity is, in general, different for the two configurations and permits a more or less clear destruction between them.

(2) The red absorption spectrum of a continuous head-to-tail chain is usually different from that of a continuous head-to-head chain and also permits to decide which configuration is present in a given material.

(3) The certain cases, there exist also chemical possibilities to distinguish between the two forms. For Polyvinylchloride, Marvel and his collaborators have shown that the chlorine can be removed by treating the dissolved polymer with zinc or copper powder. Wall and Flory have carried out a statistical consideration which leads to the conclusion that *all* chlorine can be removed from chains with thorough-going head-to-head configurations, whereas only about 87 per cent of the chlorine can be eliminated from head-to-tail chains. With the aid of this argument, Marvel could demonstrate that polyvinyl chloride exists in an almost pure head-to-tail arrangement.

Analogous conclusions are in favor of the fact that certain polyvinyl ketones and polyacrylic derivatives represent head-to-head polymers. The experimental methods, however, are usually such that a small percentage of head-to-head arrangement could not easily be discovered in a principally head-to-tail chain. On the other hand, certain physical and chemical properties of a polymer, such as solubility, thermal stability, and resistance to oxygen, might depend upon whether the substituents are regularly alternating in a one-three sequence or whether, at certain points, they are crowded into a one-two arrangement. In fact, Flory has recently demonstrated that in polyvinyl alcohol any one-two glycol configuration can be easily cleaved by the action of periodic acid and

represents a potential weak spot in the chain. In order to be fully informed about the properties of a polymer, it seems, therefore, that in principle one should know exactly the sequence of the monomer units, down to even a small number of odd arrangements. In some cases, there are experimental ways and means of establishing the existence of such flaws, but in most cases new methods will have to be worked out in order to obtain such detailed information about the structure of a polymer chain.

Branching of the chains. Another type of structural isomerism is connected with branching. Studies on the kinetics of vinyl polymerization have shown that it is possible for a macromolecule to propagate not only as a strictly linear chain, but as a more or less branched system. Polyethylene seems to be an example of a polymer which can exist in isomeric forms having different degrees of branching, and Bryant has found that this degree depends upon the mode of preparation of the polymer, such as degree of conversion, type of catalyst, *etc.* It is entirely conceivable that a polymer built of branched chains will differ in many respects from a linear material. Properties such as density, melting point, solubility, crystallizability, and compatibility with plasticizers should be expected to be noticeably different, but it is not easy, in a given case, to correlate the behavior of the material with the degree of branching because we do not have, at present, any general and reliable method of establishing the extent of branching.

Rotational Isomerism in macromolecules. Another type of isomerism of macromolecules appears to be general and may be compared with the rotational isomerism of normal organic compounds. Several years ago, it was noticed that correlation of osmotic pressure data and intrinsic viscosities of polystyrene fractions led to different results, depending upon the temperature at which the polymer was prepared. The original investigations suggested that a different degree of branching might be made responsible for this effect, but a year later Huggins advanced the idea that all vinyl polymers are subject to stereoisomerism and that this isomerism may be responsible for the different behavior of macromolecules prepared at different conditions.

The experimental evidence, at that time, was too scanty to arrive at any decisive conclusion, but recently, Schildknecht, Gross, and Zoss discovered a very spectacular case of isomerism of polyvinyl isobutyl ether, which has also been observed with other polyvinyl ethers to a somewhat lesser degree. They found that rapid polymerization of these monomers with boron trifluoride at low temperatures leads to rubbery polymers of low softening point, whereas slow polymerization of the same monomer with a moderated catalyst (boron trifluoride and dimethyl ether) yields high softening products of essentially the same molecular weight, which exhibit a distinct tendency for crystallization and are fibrous rather than rubbery. The rubbery and fibrous modifications can be recovered from their respective solutions by a precipitant, at ordinary temperatures. However, if the rubbery polymer is dissolved in a high-boiling solvent the solution is kept at elevated temperatures for a certain length of time, and the material is precipitated after cooling, the fibrous modification is obtained. The discoverers of this effect explain it by assuming that the comparatively large substituents produce enough hindrance of the rotation about the carbon-carbon bonds of the main chain to stabilize certain strongly kinked

configurations of the polymer molecule, which are reluctant to crystallize and are responsible for the rubbery modification.

This suggestion opens very interesting new aspects of the behavior of polymers with large substituents.

Consider an unbranched simple vinyl polymer such as polyvinyl chloride with head-to-tail sequence. As long as the substituents are small and their mutual interactions weak, there will be moderately hindered rotation about the individual carbon-carbon bonds of the main chain and most geometrical configurations of a macromolecule will have essentially the same potential energy. The actual shape of an individual chain or of each one in a cluster will be mainly determined by entropy considerations and the macromolecules will assume a randomly kinked configuration. The tendency to assume and maintain this most probable shape is responsible for the rubbery character of such polymers.

If the substituents become larger it will no longer be possible to accommodate them in any possible way and if we consider the extended zigzag form of the backbone chain, we will be faced with conditions as represented in FIGURE 1. Its upper part shows a head-to-tail polyvinyl chain viewed perpendicular to the plane in which all carbon-carbon bonds are contained. The points represent schematically the carbon atoms, which are 1.54 Ångstrom units apart and are of tetrahedral symmetry. Such a planar, zigzag configuration of the backbone chain fits more easily in a simple crystal lattice than any spiralized shape. This is supported by the fact that all normal paraffins and their simple derivatives crystallize in this manner and that polyethylene also favors this type of arrangement. Because of the head-to-tail character of the polymer, all substituents have to be arranged in FIGURE 1 on the same side of the chain (above or below), if we want to preserve the extended form of the chain and with it the easy crystallizability of the polymer.

There exist, however, two possibilities for the arrangement of the substituents on one side of the backbone chain: One in which all substituents are on the same side of the plane in which the zigzag of the carbon-carbon chain is contained (such as in the lower part of FIGURE 1), and another in which the substituents are alternately before and behind this plane. If these substituents are large or bulky, the lowest potential energy will be correlated to a chain in which the substituents alternate. The lower parts of FIGURES 1 and 2 are intended to clarify this situation. In them we look at the chain parallel to the plane which contains the carbon-carbon zigzag. In terms of the upper parts we look at the chain from above and we see now the subsequent carbon atoms of the main chain as a straight line and the substituents emerging from each carbon atom in a zigzag arrangement, right-left-right-left, etc.

The chain configuration as represented in FIGURES 1 and 2 represents a successful compromise of two facts: a low potential energy because of the zigzag arrangement of the substituents as soon as they are large and bulky (as shown in FIGURE 2), and easy crystallizability because of the planar zigzag arrangement of the carbon atoms of the main chain.

If a long-chain molecule is formed in the course of a slow and mild reaction, it seems not unreasonable to assume that this is the configuration which will be preponderantly formed. That does not mean that in the reaction mixture all chains will be rigid and straight, but it implies that the macromolecules will have only moderate

bends and no sharp or sudden kinks. In the sense of Huggins, this is an arrangement of the substituents in which *d* and *l* configurations alternate regularly as one travels along the chain in its straightened out planar zigzag form.

Whenever this chain type is preponderant, we shall expect the high softening, easy crystallizable fibrous modification of a polymer.

considerable activation energy, which may assume values of 8000 cal. per mole or more. After rotating the 6–7 bond about 150° or 180°, substituent 4 can again be reasonably accommodated between 3 and 5; not so well as in the straight-chain configuration of FIGURES 1 and 2, but not very much worse. In terms of potential energy, this means that substituent 4 is now vibrating in a potential energy valley, which is

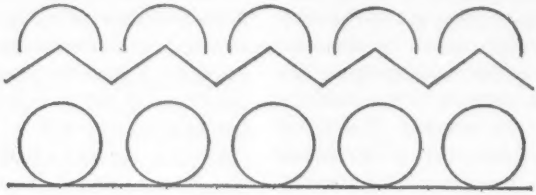

FIGURE 1

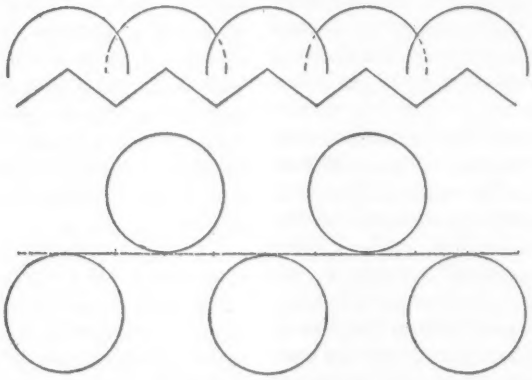

FIGURE 2

Now assume that we carry out a rotation of about 150° to 180° about one carbon-carbon bond of the chain, say about bond 6–7 in FIGURE 2, in such a manner that substituent 4 is now out of phase with the regular right-left alternation as shown in FIGURE 2. In order to achieve this rotation, it will be necessary to move substituent 4 in close proximity to substituents 3 and 5. Because of their bulk or their polar interaction, this may require a not so deep as before (maybe 3000 to 4000 cal. per mole higher) and which is separated from the previous valley by a potential energy barrier of 8000 cal. per mole or more.

The most important change after this rotation is that the main chain now forms a relatively sharp kink at carbon atom 7. FIGURE 3 gives an ideal of this condition. The part of the chain which contains substituents 4 and 5 was swung around and

forms an angle of about 90° with its previous direction. This kink is, of course, not strictly permanent, because it can be removed by turning the chain back into its original shape, but it is stabilized by an appreciable activation energy because of the interaction of the substituents and will, therefore, be relatively stable at moderate temperatures.

If a chain once possesses a certain number of such kinks, it will not be straightened out so easily, except by prolonged heating in the dissolved or plasticized state. On the other hand, chains with

FIGURE 3

frequent kinks will fit in a crystal lattice only difficultly and will therefore exhibit a more rubbery character than chains corresponding to FIGURES 1 and 2.

It seems not too unreasonable to assume that in a rapid reaction the addition of the individual monomers to the growing chain will not always be in accord with the absolute minimum of the potential energy. Once in a while a substituent will not be arranged as FIGURE 2 prescribes, but as FIGURE 3 shows for substituent 4. If this happens, on the average, after twenty monomers, the chain is of a very crooked shape, which makes crystallization virtually impossible. If chains of such nature prevail, we have the rubbery modification of a polymer.

Depending upon size and interaction of the substituents, this rubbery modification will exhibit a certain stability but will on prolonged heating eventually isomerize into the fibrous form.

Polyvinyl isobutyl ether seems to be a particularly clear case of this type of isomerism, which has a distinct similarity to the rotational isomerism of ordinary organic compounds, and which, according to Schildknecht, Gross, and Zoss, seems to exist with other polyvinyl ethers. There is evidence that polyvinyl chloride also shows this phenomenon of rotationl isomerism to a certain degree. Experiments of Alfrey, Badgley, and Mesrobian have demonstrated that preheating of polyvinyl chloride in solution or in a highly plasticized state increases the tendency of the polymer to crystallize and makes it more difficultly plasticizable. In fact, the kinks of the main chain, which are stabilized by steric hindrance through the substituents, act like an ingrown plasticizer, which is very effective in preventing crystallization and maintaining rubberiness but can be gradually smoothed away by an appropriate heat treatment.

Thus, certain polymers can have different properties if they have been prepared under different conditions, not because of head-to-tail, head-to-head isomerism and not because they represent different degrees of branching, but simply because the substituents are differently arranged in space as we progress along the chain and affect the configuration of the chain as a whole.

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CONFERENCE HELD

SECTION OF BIOLOGY

CONFERENCE ON "METHODOLOGY AND TECHNIQUES FOR THE STUDY OF ANIMAL SOCIETIES": NOVEMBER 12 AND 13, 1948

The section of Biology and The New York Zoological Society, held a Conference on "Methodology and Techniques for the Study of Animal Societies." Doctor J. P. Scott, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, was the Conference Chairman in charge of the meeting.

The program consisted of the following papers:

Friday, November 12

Morning Session. "Introductory Remarks," by Harden F. Taylor, President, The New York Academy of Sciences, and Fairfield Osborn, President, The New York Zoological Society.

"Plans and Methodology for Field Studies of the Naturalistic Behavior of Animals," by C. R. Carpenter, Pennsylvania State College, State College, Pa.

"The Social Behavior of Dogs and Wolves; an Illustration of Sociobiological Systematics," by J. P. Scott, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me.

"The Relationship Between Observation and Experimentation in the Field Study of Behavior," by T. C. Schneirla, American Museum of Natural History, New York, N. Y.

Afternoon Session. Chairman, Robert K. Enders.

"Measurement of Some Physiological Reactions to Natural Conditions," by Laurence Irving, Arctic Research Laboratory, Point Barrow, Alaska.

"Instruments for the Measurement of Emotional Reactions of Unrestrained Animals," by J. L. Fuller, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me.

"Effects of Nutrition and Diseases on Experimental Animals," by L. J. Goss, New York Zoological Society, New York, N. Y.

Evening Session. "A Study of the Phylogenetic or Comparative Behavior of Three Species of Grouse," by J. W. Scott, University of Wyoming, Laramie, Wyo.

Saturday, November 13

Morning Session. Chairman, Frank A. Beach.

"Animal Societies and the Individual," by N. E. Collias, University of Wisconsin, Madison, Wis.

"Isolation of Factors of Learning and Native Behavior in Field and Laboratory Studies," by B. F. Riess, American Museum of Natural History, New York, N. Y.

"Techniques for the Study of Bird Societies Under Natural Conditions," by J. T. Emlen, Jr., University of Wisconsin, Madison, Wis.

"The Study of Wild Populations Under Controlled Conditions," by John B. Calhoun, Johns Hopkins University, Baltimore, Md.

NEW MEMBERS

Elected November 20, 1948

LIFE MEMBERSHIP

Wallis, Robert, M.D., Biology, Psychology. Roosevelt Hospital, New York, N. Y.

SUSTAINING MEMBERSHIP

Balassa, Ladislaus, Ph.D., Chemistry. Research Director, U. S. Finishing Company, Providence, R. I.

Thorek, Max, M.D., LL.D., D.Sc., Surgery. International Secretary General, International College of Surgeons, Chicago, Ill.

Winkelman, Nathaniel W., M.D., Neuropsychiatry and Neuropathology. Professor of Neuropathology, University of Pennsylvania, Philadelphia, Pa.

ACTIVE MEMBERSHIP

Abelson, Philip H., Ph.D., Biochemistry, Biophysics, Cell Physiology. Staff Member, Carnegie Institution of Washington, Washington, D. C.

Alpert, Barnett, M.D., Biophysics. Attending Physician, King's County Hospital, Brooklyn, N. Y.

Amler, Alfred B., M.D., Pediatrics. Assistant Attending Pediatrician, New York Post Graduate Medical School & Hospital, New York, N. Y.

Beck, Raymond, A.B., Biology. Laboratory Assistant, Schering Corporation, Bloomfield, N. J.

Boettiger, Edward G., Ph.D., Physiology. Assistant

Professor of Zoology, University of Connecticut, Storrs, Conn.

Boyack, Gerald, Ph.D., Chemistry. Associate, Squibb Institute for Medical Research, New Brunswick, N. J.

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Daniel, Earle H., Prosthetic Appliances. Director of Prosthetic Service, New York University Institute of Rehabilitation and Physical Medicine, New York, N. Y.

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